GRADUATE STUDENT TRAINING IN ENGINEERING: INSTRUMENTING THE CONTINENTAL SHELF WAVE BOTTOM BOUNDARY LAYER

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LONG-TERM GOALS

My long-term goals are to develop instruments to observe physical phenomena responsible for mixing the ocean, suspending and transporting sediment at the bottom, and entraining air and momentum at the surface under wind and waves.

OBJECTIVES

Education of students within the WHOI/MIT Joint Graduate Program in Oceanographic Engineering enables me to achieve these long term goals if I can train particular students in measurement and instrumentation. My objective in this effort is to train a student in making critical instruments and measurements with these instruments to understand wave processes in the bottom boundary layer on the continental shelf.

APPROACH

At the start of this research program, Archie Todd Morrison III was completing his PhD under my supervision on the development of the BASS Rake, a device based upon BASS, to measure the velocity profile with 1 mm vertical resolution in the bottom 10 cm of the water column in a wave environment. In May, 1997, Todd finished his thesis and the support was transferred to William J. Shaw who had been working on measurement of heat flux in the benthic boundary layer with BASS. Thus, two students have been supported under this project, each working on measurement of benthic mixing processes under waves.

WORK COMPLETED

Support under this grant permitted Todd Morrison to complete the prototype field BASS Rake instrument, to obtain a data set at Nobska beach under waves in December, 1996, and to analyze the data set for his thesis, successfully defended in May, 1997. Support under this grant, after Todd finished his thesis and was no longer a student, passed to Bill Shaw to allow him to study heat flux and salinity flux under waves in the Coastal Mixing and Optics experiment. Bill had implemented a circuit to be added to BASS to obtain precise acoustic travel time measurements which was augmented in April with thermistors on the CMO BASS tripod so that speed of sound fluctuations could be compared with temperature fluctuation in the sensor volume to obtain salinity fluctuations. (Speed of sound, measured by the new circuit, is influenced by both temperature and salinity. By knowing the fluctuation in temperature as well as the fluctuation in speed of sound, one can determine fluctuation in salinity.) Data were recovered in the period April to August, 1997 from these measurements.

RESULTS

Todd Morrison observed rapid sand ripple formation under 5 second waves in 3 meters depth over a smoothed sand bed. Within a tidal period, the ripple crest grew and obscured three acoustic paths of 7.5 cm in depth. Instantaneous profiles of the wave velocity over a single wave cycle show accelerated flow at the lowest acoustic paths due to acceleration over the ripple. The significance of this observation is that a new profiling technique has been developed that is synoptic over the relevant profile for the wave boundary layer capable of resolving speed, height, and direction of flow in the lowest 10 cm of the water column. The transducer spacing was 2.5 cm rather than the 0.1 cm spacing first designed and tested in a flume. This prevented the actual wave boundary layer from being separated from the current boundary layer. The time limits of the thesis forced a demonstration of the electronic and mechanical developments without the final transducer encapsulation needed to move the flume version into the field. This is now being done but falls outside the tasks supported by this grant. This work has been reported in Todd's thesis and an Oceans 97 IEEE/MTS paper.

Bill Shaw has reported early measurements of temperature fluctuations (speed of sound fluctuations) from the circuit added to the CMO BASS instrument in an Oceans 96 IEEE/MTS paper. This preceded support under this grant. Additional work to separate the salinity part of the speed of sound fluctuations from the temperature fluctuations is proceeding but has not yet achieved results ready for reporting. The salinity fluctuations at the CMO site are small so the signal in this case is not strong; the speed of sound fluctuations can nearly all be accounted for by the fluctuations in temperature. While this result is null for salinity flux at the CMO site, it shows the sensitivity of the technique for estuarine mixing where salinity flux must be great.

IMPACT/APPLICATIONS

A BASS Rake is being built under NSF support for deployment at Duck, N.C. after the main instrument suite of SandyDuck is removed in December, 1997. The impact of the development of the BASS Rake under support from this grant is that this field instrument can be completed within the extended field program of SandyDuck. It is my belief that this instrument will be a valuable addition to coastal measurement toolkits.

Salinity flux is a poorly understood process in estuaries; at least the physical processes responsible for mixing salinity are not well understood. Addition of a capability to measure salinity flux in the same volume as we presently measure momentum flux is another valuable addition to our toolkit.

TRANSITIONS

BASS Rake is planned to be co-deployed with the ADV array of Trowbridge and Voulgaris in December, 1997 at Duck. The very near bed measurements this instrument produces will be utilized by these scientists. The instrumentation will be offered to others measuring bottom stress and sediment transport under waves in shallow water. A collaboration is planned with Jim Irish and Peter Traykovski of WHOI to measure the bedload and suspended load on sand ripples under waves at LEO-15.

Salinity flux will routinely be measured on future BASS tripods in use in CMO, Hudmix, and future experiments in estuaries.

RELATED PROJECTS

3-D Acoustic Current Measurement is an NSF grant to develop low cost, highly capable current measurement techniques. The BASS Rake is now being developed under that support due to the close relation between the tasks of each project. The field instrument is being built for demonstration under NSF support.

Hudmix was a predecessor of the current AASERT. It was an NSF grant to study mixing of the Hudson estuary. It provided the initial support for Bill Shaw to add a circuit to BASS to measure absolute travel time and thus measure speed of sound fluctuations. The work was continued under this AASERT to add thermistors and permit salinity flux to be backed out of the speed of sound measurements. Since the salinity flux signal is small in the present experiment, it will be necessary to couple the salinity flux measurement with a yet-to-be funded estuarine study.

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